

BIOLOGICAL EVALUATION OF GYPSY MOTH

at

ANDREWS AIR FORCE BASE

2008

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ABSTRACT

On September 9, 2008, USDA Forest Service personnel conducted a gypsy moth egg mass survey at Andrews Air Force Base. The purposes of this survey were to determine population densities, evaluate the efficacy of this year's treatment, assess the potential for defoliation and the need for treatment in 2009. Current populations are sufficient to cause light defoliation on 3.85 acres in 2009. Treatment is recommended to prevent defoliation, branch dieback and possible tree mortality.

METHODS

Gypsy moth survey plots were randomly selected based upon available host trees (oak species), size of sample area and uniformity between egg mass counts. At each sample point, a 1/40th acre fixed radius plot was established. The plots consisted of a tally of all the new (2008) egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre. Egg mass lengths were also measured at the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity.

RESULTS

The location of the survey plots along with the three Dimilin treatment areas are shown in Figure 1. The summarized results are presented in Table 1. In brief, egg mass densities at Andrews Air Force Base (Andrews AFB) ranged from 0-1720 and averaged 176 egg masses per acre. Overall egg mass lengths tended to be moderate in size, ranging from 24-36 mm and averaging 30 mm.

Egg mass densities in the treatment areas ranged from 0-80 and averaged 17 egg masses per acre which is a 99.5 percent reduction from the pre-treatment level (2007) of 3276 egg masses per acre. Egg mass lengths in the treatment areas averaged 31 mm.

The highest gypsy moth population levels were found on the golf course south of Perimeter Road near Wheeling Road. Egg mass densities in this area (plot #s 12, 13, 17 and 19) ranged from 360-1720 and averaged 1080 egg masses per acre. Egg mass lengths ranged from 24-36 and averaged 30 mm. A few of the trees in this area were defoliated this year.

The infested trees were comprised by groves of trees, small woodlots and small portions of woodlots.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include; previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (30-50 percent); or heavy (51-100 percent). Defoliation less than 30 percent has little impact on trees and can not be detected through an aerial survey.

The egg mass survey results indicate that light defoliation totaling 3.85 acres is likely to occur in an area south of the Perimeter Road near Wheeling Road at Andrews AFB in 2009 (Figure 2).

This conclusion is further supported when egg density is used as a means of predicting defoliation. Moore and Jones (1987) found that estimating the mean fecundity will increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, Figure 3 shows how this information can be used to correlate the predicted defoliation of an area. Accordingly, the estimated egg mass density of 1080 egg masses per acre (average egg mass density in the area south of Perimeter Road near Wheeling Road) x 30 mm (average egg mass length in the area south of Perimeter Road near Wheeling Road) translates to a projected defoliation level of about 36 percent (light defoliation). Because egg mass densities and the host type are not evenly distributed, actual defoliation will vary from tree to tree but will be predominantly light throughout this area of Andrews AFB.

Based on existing egg mass densities and the general size of egg masses, gypsy moth populations appear to be healthy in areas where they were detected at Andrews AFB. The average egg mass length is 31 mm. Egg masses larger than 25 mm typically indicate healthy populations with no obvious stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining or stressed populations. There was no evidence that either one of these entomopathogens had significant impacts at Andrews AFB in 2008. Although it is still possible that either the gypsy moth fungus or the NPV could cause the general collapse of the gypsy moth population next year, it is unlikely that populations will collapse prior to defoliation occurring in 2009.

Predicting the extent of tree mortality that would occur after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. Trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light defoliation (<50 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. Individual and small groups of trees were defoliated by gypsy moth at Andrews AFB in 2007 and 2008 although no defoliation was detected in any of the three treatment areas in 2008. Also, Andrews AFB experienced droughty conditions during the 2007 growing season and again late in the 2008 growing season.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) provide examples of the potential tree mortality that can occur. On the Allegheny National Forest, untreated

stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28 percent) following one year of defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63-78 percent of the species composition, a loss of 25 percent of the total oak saw timber and 14 percent of the total oak pole timber occurred after one year of light to heavy defoliation. In these examples, droughty conditions likely contributed to the level of mortality.

Based on observations of the existing health of the trees at Andrews AFB and the factors mentioned above, branch dieback and tree mortality are likely if the defoliation occurs. The branch dieback and tree mortality will likely be on individual trees or small groups of trees. This branch dieback and tree mortality will be more prevalent if adequate rainfall is not received during the 2009 growing season and if the defoliation occurs on the same trees that were defoliated in 2007 or 2008.

Management Options

In 2009, three management options have been evaluated for managing gypsy moth populations at Andrews AFB. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage to prevent branch dieback and tree mortality; and 2) reduce gypsy moth population below the treatment threshold. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga*. In areas with defoliating levels of gypsy moth populations, viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels.

Although it is not possible to accurately assess such events with the defoliating levels and then collapse as a result of NPV or fungal activity. Residual populations information at hand, it is unlikely that a collapse will occur in 2009 since most this area south of Perimeter Road near Wheeling Road is newly infested and the egg masses appear to be healthy

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al., (1996) showed short-term impacts of both species richness and abundance occurred following light defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that light defoliation will occur in the area of Andrews AFB depicted in Figure 2.

Microbial Insecticide Option

Btk: The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringiensis* variety *kurstaki* (*Btk*). This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are actively feeding at the time of treatment. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al., (1996) in West Virginia. Miller's study involved a large scale (5,000 acres) eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1 year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½ -1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely.

Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult at best to project treatment efficacy. Most often foliage protection can be achieved but significant reductions in gypsy moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 4×10^{11} occlusion bodies (OB's) per acre applied in a single application or 2×10^{11} OB's per acre applied in a double application. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments. There are, however, sufficient quantities of Gypchek currently available for 2009 should this insecticide be preferred for use at Andrews AFB.

Chemical Insecticide Option

The third option is to use a chemical insecticide to control gypsy moth populations. There is currently one chemical insecticide registered for control of gypsy moth populations and approved by the USDA Forest Service for use in cooperative gypsy moth control programs.

Dimilin® (diflubenzuron) is the most widely used chemical insecticide in gypsy moth suppression projects in the U.S. and is registered by the EPA for use in residential areas. Diflubenzuron (DFB) is an insect growth regulator that disrupts the normal molting processes of the larvae. The mode of action is to inhibit the formation chitin, a necessary component of the outer cuticle which causes the affected larvae to die during the molt following treatment. The method of uptake is primarily by ingestion, however some research has indicated the possibility of absorption through the cuticle as well. DFB is relatively persistent on foliage (24 days) which increases the efficacy on gypsy moth populations but also exposes non-target insects, particularly caterpillars, for a greater period of time.

DFB is extremely toxic to some aquatic invertebrates and the label prohibits the application over open water or wetlands. DFB is available as an oil based liquid formulation (Dimilin® 4L) and is normally applied in a single application at the standard rate of 1-2 ounces of formulated material per acre. With proper application, foliage protection and a significant population reduction can be expected. The need for treatment of residual populations the following year is normally not necessary.

Alternatives

With the previously described options in mind, the following alternatives are offered:

Alternative 1 - No action.

Alternative 2 - One aerial application of *Btk* at the rate of 36 BIUs in a total mix of $\frac{3}{4}$ gallon per acre

- Alternative 3 - Two aerial applications of *Btk*, as in alternative 2, applied 4-7 days apart.
- Alternative 4 - One ground application of *Btk* at the rate of 36 BIUs in a total mix of 1 gallon. The amount of spray material needed will vary from tree to tree depending on size of the tree.
- Alternative 5 - One aerial application of Gypchek at the rate of 4×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.
- Alternative 6 - Two aerial applications of Gypchek at the rate of 2×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.
- Alternative 7 - One aerial application of DFB at the rate of 1.0 oz formulated material in a total mix of 1 gallon per acre.
- Alternative 8 - One ground application of DFB applied at the rate of 1.0 oz formulated material in a total mix of 1 gallon. The amount of spray material needed will vary from tree to tree depending on size of the tree.

RECOMMENDATIONS

As previously stated, gypsy moth populations are sufficient to cause light defoliation on 3.85 acres at Andrews Air Force Base in 2009. To protect tree foliage and to prevent branch dieback and tree mortality, our recommendation is alternative 2 (a single application of *Btk*).

This recommendation is based on the following considerations:

- 1) Gypsy moth population levels are not sufficient to warrant a double application of *Btk* (alternative 3) or a single application of DFB (Alternative 7)
- 2) A single application of *Btk* is likely to provide both foliage protection and a significant gypsy moth population reduction.
- 3) It is a more economical choice than a single application of Gypchek (Alternative 5) or a double application of Gypchek (Alternative 6).
- 4) This recommendation is also based on the assumption that these 3.85 acres can be sprayed under a Maryland Department of Agriculture spray contract or under a county contract. It would not be economical to have a separate suppression contract for such a small amount of acres.

If these 3.85 acres can not be treated aerially, our recommendation is alternative 4 (a single ground application of *Btk*) or Alternative 8 (a single ground application of DFB).

REFERENCES

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- Gottschalk, K.W. 1990. Gypsy moth impacts on mast production, *In*: McGee, Charles E. Ed. Proceedings of the Workshop, southern Appalachian Mast Management; 1989 August 14-16; Knoxville TN; University of Tennessee; 42-50.
- Liebhold, A.M., Simons, E.E., Sior, A., and Unger, J.D. 1993. Forecasting defoliation caused by the gypsy moth from field measurements. *Environ. Entomol.* 22(1): 26-32.
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- West Virginia Division of Forestry. 1997. *In* 1997 Cooperative State-County-Landowner Gypsy Moth Suppression Program in West Virginia. 3p. (Brochure).

Table 1 – Gypsy moth egg mass survey results at Andrews Air Force Base
September 9, 2008

Plot #	# em/acre	em size (mm)
1	0	--
2	0	--
3*	80	32
4	0	--
5*	0	--
6*	0	--
7*	0	--
8*	0	--
9*	0	--
10	0	--
11*	80	30
12 ^z	360	28
13 ^z	1720	30, 28
14	80	32
15	0	--
16*	40	--
17 ^z	1520	24, 34
18*	0	--
19 ^z	720	36
20	0	--
21	0	--
22	0	--
23*	0	--
24*	0	--
25	0	--
26*	0	--

overall egg masses/acre range = 0-1520

overall egg masses/acre average = 176

overall egg mass size range (mm) = 24-36

overall egg mass size average (mm) = 30

*= plot located within Dimilin treatment area

egg masses/acre range in treatment areas = 0-80

egg masses/acre average in treatment areas = 17

egg mass size range (mm) in treatment areas = 30-32

egg mass size average (mm) in treatment areas = 31

^z = plot located within recommended treatment area

egg masses/acre range in recommended treatment area = 360-1720

egg masses/acre average in recommended treatment area = 1080

egg mass size range (mm) in recommended treatment area = 24-36

egg mass size average (mm) in recommended treatment area = 30

Figure 1. -- Locations of the gypsy moth egg mass survey plots established on September 9, 2008, along with the 2008 gypsy moth treatment blocks.

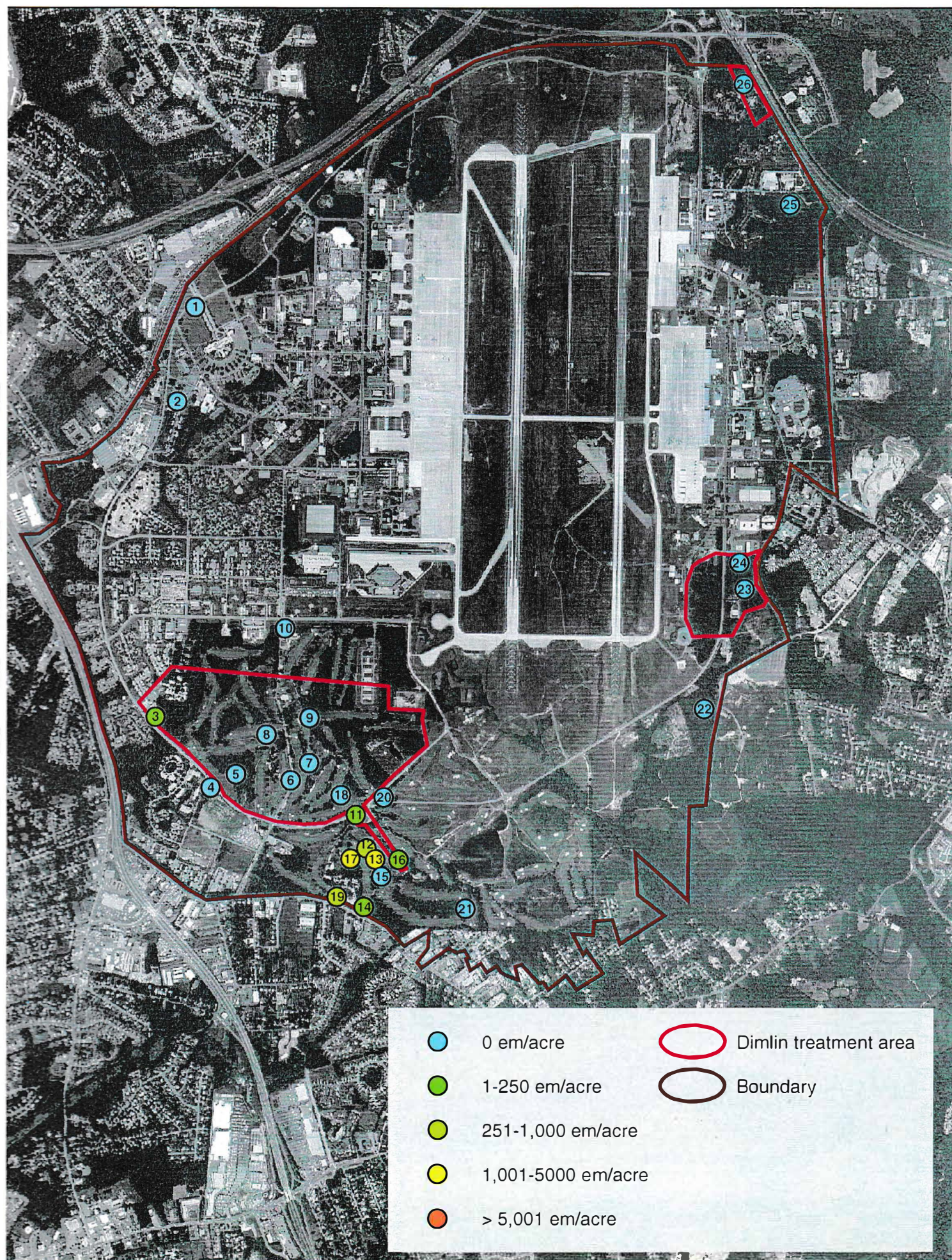
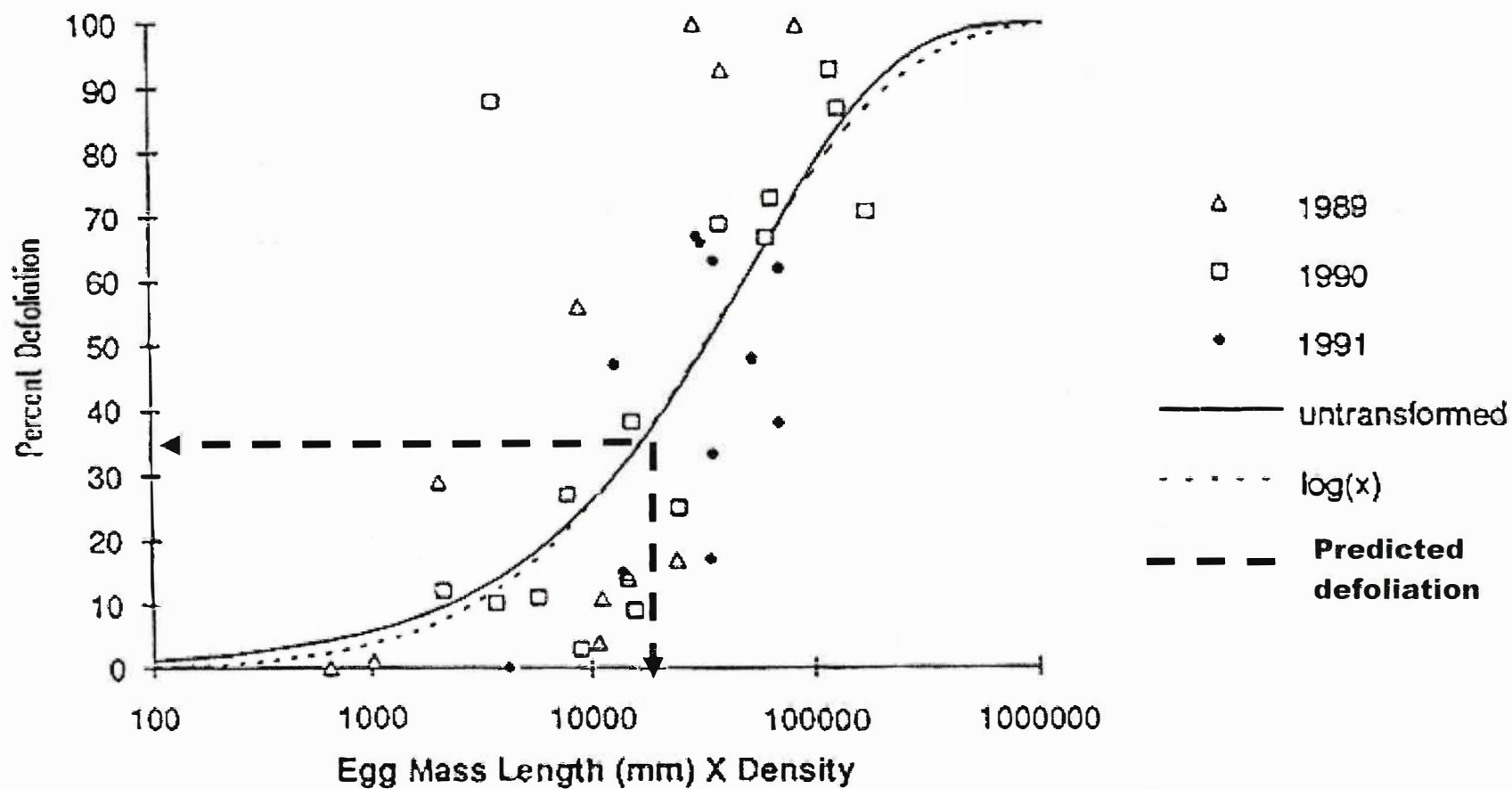


Figure 2. -- Area where defoliation is likely/Proposed treatment areas at Andrews Air Force Base.



Figure 3.—Predicted defoliation in the area south of East Perimeter Road near Wheeling Road at Andrews AFB in 2009.



Scatter plot of the product of mean egg mass length and egg mass density versus mean defoliation.
Extracted from Liebhold et al. (1993).



United States
Department of
Agriculture

Forest
Service

Northeastern Area
State and Private Forestry

180 Canfield Street
Morgantown, WV 26505-3101

File Code: 3400
Date: October 1, 2008

Ms. Anne Kaval
316 CES/CEV
3466 North Carolina Avenue
Andrews Air Force Base, MD 20762-4802

Dear Anne:

Enclosed is the gypsy moth biological evaluation for Andrews Air Force Base.

In brief, gypsy moth populations are sufficient to cause light defoliation on 3.85 acres. If this defoliation interferes with your management objectives of this area, we recommend a single aerial application of *Bacillus thuringiensis* variety *kurstaki* (Btk) or a single ground application of either Btk or Dimilin® (diflubenzuron).

Please contact me at 304-285-1555 if you have any questions regarding this gypsy moth biological evaluation.

Sincerely,

RODNEY L. WHITEMAN
Forester
Forest Health Protection

Enclosure

Cc: Patricia Gray, Andrews AFB
Steve Tilley, MDA
Linda Scott, MDA
Pete Egan, Armed Forces Board
Robert Lueckel, MFO

